# *FINAL RESTORATION PLAN*

**Neponset River Salt Marsh**
**Mitigation and Restoration Project**

**Boston, Massachusetts**

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# 1. INTRODUCTION

## 1.1 Overview

The purpose of this report is to document the planning stages and provide details that support the *Final Restoration Plan* for the Neponset River Salt Marsh Restoration project. The Metropolitan District Commission (MDC) is undertaking the restoration project. The project is being coordinated as part of a state and federal Coastal America partnership and funded through a grant from the US Fish & Wildlife Service. A secondary component of the project focuses on providing adequate mitigation for salt marsh alteration (0.56 acres) associated with the Savin Hill/Inner Malibu Beach project. The mitigation component of this plan will be integrated within the larger restoration project. Therefore, the elements of the restoration and mitigation phases have been carefully selected so as to complement each other.

The restoration site is located within the Neponset River estuary, on land owned by the MDC. Much of the southern portion of the project site was altered extensively during the mosquito ditching in the 1950s and Neponset River dredge spoil disposal in the 1960s. A network of dikes was created along and within the site to contain and control the dredge spoil pumped from the river. The restricted tidal flows within the site have resulted in alterations to the elevations and tidal hydrology that have created favorable conditions for the colonization and expansive growth of common reed (*Phragmites australis*). The dominant and invasive reed has largely overtaken the native salt marsh plant community.

In order to establish the foundation for restoration planning the report includes the following sections:

- Brief History of the Site;
- Goals and Objectives of the Restoration;
- Overview of the Regulatory Permitting;
- Description of Existing Site Conditions;
- Basis for the Restoration Plan;
- Details of the Proposed Restoration Plan.

## 1.2 History of Land Use

The proposed Neponset Salt Marsh Restoration site is part of the extensive Neponset estuary. Based on a preliminary review of local history it appears the estuary remained in a relatively undisturbed natural state until approximately the 1920s-1930s (Palmer, 1997). During the 17$^{th}$ and 18$^{th}$ centuries, the marsh grasses within the estuary along the Neponset River served as summer pasturage for livestock. The marsh also produced hay that was cut and stored for winter fodder (MDC, 1996a; Vandermark, 1993). Historic records indicate that in the late 1800s a small pond was

centrally located within the restoration site. The acquisition of the Neponset marshes by the Metropolitan Park Commission (MPC) (predecessor of the Metropolitan District Commission [MDC]) began in 1896. The Neponset marshes were the first in the Commonwealth to be protected as natural assets.

In the early 1900s residential development began to encroach on the western side of the Neponset marsh restoration site. The landward dikes bordering the upland portion of the marsh may have been placed along with fill prior to World War II. Aerial photos in 1952 (1952 [DPU 8K 85R]) provide the first evidence of mosquito-ditching extending into the restoration site from the Neponset River. This photograph also shows construction activity related to the installation of the Massachusetts Water Resources Authority (MWRA) water main that parallels Palmer Creek. An additional photo taken in 1970 (1970 [DPS 5LL 101]) shows that there were additional dikes and fill placed on the seaward section of the marsh since the 1952 photograph.

## 1.3 Goals and Objectives of Preliminary Restoration Plan

The goal of the restoration is to replace existing low quality habitat with a self-sustaining "low salt marsh" with minimum long-term maintenance. The primary objective is to accelerate the restoration by increasing the tidal exchange and lowering the marsh elevations within the site. The total area targeted for restoration includes approximately 20 acres. Tidal flows will be increased by a combination of ditching (creation of new ditches and extension/expansion of existing ditches), excavation of pools, and breaches in the existing dikes. The increased tidal interaction and salinities entering the site will encourage native salt tolerant marsh species, and discourage the growth and expansion of the common reed. The development of a series of creeks, ditches and pool complex of varying depths and drainage regimes will function to create variation in the wildlife habitat.

## 1.4 Compensatory Mitigation

This restoration project incorporates an approximately 1.2-acre area that represents mitigation for impacts associated with the construction the Savin Hill/Inner Malibu Beach project proposed by the MDC. The Savin Hill/Inner Malibu Beach project includes alteration of 0.56 acres (24,400 s.f.) of salt marsh located along the shoreline of the beach. Approximately 455 c.y. of salt marsh will be dredged and disposed of at an upland location and 5,500 c.y. of sand compatible with the existing beach will be placed below the high tide line. A Variance under the Massachusetts Wetlands Protection Act, a 401 Water Quality Certificate and an Interim Assessment from MEPA has been obtained for this work. In addition, the Army Corps of Engineers has issued a conditional approval under Section 404, pending the receipt and approval of this restoration plan. The remaining permits required for mitigation will be combined with the permits required for the overall restoration project.

## 1.5 Regulatory Permitting

It is anticipated that the following environmental permits and approvals will be required in order to proceed with the implementation of the restoration and mitigation components of this project:

- US Army Corps of Engineers – Department of the Army Section 404 Permit;
- 401 Water Quality Certificate;
- Massachusetts Wetlands Protection Act - Order of Conditions;
- Chapter 91 Waterways License - Determination of Jurisdiction;
- Coastal Zone Management Consistency Review;
- MEPA approval; and
- National Pollution Discharge Elimination System (NPDES) Permit - Construction Activities

# 2. EXISTING CONDITIONS

## 2.1 Introduction

This section of the *Final Restoration Plan* presents information on the existing conditions within the restoration site. The descriptions focus on the primary conditions within the site including topography, vegetation, soils, hydrology and salinity. The understanding of these characteristics within the site provide a framework for making restoration decisions. In addition, this information will be useful as a basis for comparison with post-restoration conditions.

## 2.2 Site Location and General Site Features

The Neponset restoration site is located on the west bank of the Neponset River in the city of Boston on MDC property (see Figure 2-1). The site is within a larger estuary system associated with the lower tidal reaches of the Neponset River. The project area that encompasses the restoration site is approximately 40 acres. The northern edge of the site is bordered by the existing Massachusetts Water Resources Authority (MWRA) water main easement. Palmer Creek is a small tidal creek that flows along the easement separating the restoration site from additional marsh areas to the north. The Neponset River borders the eastern and southern edges of the site. Ventura Playground and a residential area border the western edge of the site.

The perimeter of the restoration site has been altered extensively due to the creation of dikes and disposal of dredge spoil. A network of dikes was created along and within the site to contain and control the dredge material pumped from the river. The restricted tidal flows within the site have resulted in alterations to the ground and surface water hydrology and salinity that in turn have created favorable conditions for the colonization and growth of common reed (*Phragmites australis*). The invasive reed within many areas of the site has largely obliterated the native salt marsh plant community.

## 2.3 Topography

The topographic information on the project site (40 acres) is derived from a survey conducted in the summer of 1998. The purpose of the survey was to identify the elevations and general physical features within the site. The survey in the field was generated based on the establishment of a grid pattern throughout the site. The existing gravel road on the MWRA easement was used as a baseline for establishing transects within the grid. Nine transects, spaced at 200-foot intervals, were

Figure 2-1: Project Locus Map

established perpendicular to the baseline. Individual plots were located at 200-foot intervals along each transect. The baseline and individual plots along each transect were surveyed and staked in the field.

The survey not only provided topographic information but also reference stations for the remaining field sampling efforts. The results of this topographic survey are presented on the attached Existing Conditions Plan (see Appendix B).

The restoration site is located within a meandering, low-gradient section of the Neponset River. The site is segmented into separate cells by the earthen dikes. These dikes isolate most of the restoration site from hydrologic exchange with the adjacent Neponset River. The largest cell, closest to the river, is the area targeted for the restoration. This cell is enclosed on all sides by the dikes. The remaining two cells are located landward with dikes that run perpendicular to the primary cell. The dikes range in height from 3 to 6 feet above adjacent marsh elevations. Elevations within the restoration site are highest in the northeast corner (~9 feet NGVD) and lowest in the southwest corner (~4 feet NGVD).

## 2.4 Vegetation

Information on vegetation within the restoration site was compiled from previous inventories and a detailed field-sampling program. The field-sampling program utilized the grid pattern established for the topographic survey as described. At each sampling station along the transects, a 3×3 meter plot was established to compile data on the plant community type, dominant plant species, and general percent cover. Species occurrence was classified as dominant (>51%), abundant (26-50%), common (6-25%) and scarce (<5%) within each plot.

The information obtained in the vegetation sampling was used in combination with interpretation of an orthophoto/color-infrared aerial photograph to develop a vegetation cover map. The major vegetative communities were identified and delineated based upon dominant plant species associations as shown in Figure 2-2.

Based on the cover type mapping and vegetation sampling results, it was determined that much of the approximately 40-acre restoration site presently contains dense stands of common reed (*Phragmites australis*). In many areas, *Phragmites* sp. occurs at densities high enough to virtually exclude all native salt marsh species. These stands are occasionally interspersed with patches of native salt marsh vegetation. Remnant areas of high marsh are found in the vicinity of several small pools and pannes, which still exists in the southern portions of the site. These patchy high marsh areas are dominated by salt meadow cordgrass (*Spartina patens),* saltmarsh bulrush *(Scirpus robustus)* and salt grass *(Distichlis spicata)*. Narrow bands of low marsh, dominated by salt marsh cordgrass (*Spartina alterniflora)* occur, immediately bordering creeks and ditches in the northern portion of the site.

Figure 2-2: Neponset Salt Marsh Cover Type Map

***Vegetation Cover Types***

| Vegetative Type | Symbol | Representative Species |
|---|---|---|
| Saltmarsh | SM1 | *Spartina patens, Spartina alterniflora, Distichlis spicata* |
| | SM2 | *Spartina alterniflora, Spartina patens* |
| | SM3 | *Iva frutescens, Solidago sempiverens, Spartina patens, Distichlis spicata* |
| | SM4 | *Spartina patens, Scirpus robustus, Distichlis spicata* |
| *Phragmites* | P | *Phragmites australis* |
| Upland | UP1 | *Rhus typhina, Rhus ideus, Rubus allegheniensis, Solidago rugosa* |
| | UP2 | *Rhus typhina, Phragmites australis, Rosa rugosa, Robinia Pseudo-acacia, Prunus serotina* |
| | UP3 | *Robinia Pseudo-acacia, Rhus typhina, Rosa multiflora* |
| Emergent Marsh | EM1 | *Spartina pectinata, Solidago rugosa, Solidago tenuifolia* |
| | EM2 | *Solidago rugosa, Solidago tenuifolia, Spartina pectinata* |
| | EM3 | *Spartina pectinata, Panicum varigatum, Solidago rugosa, Andropogon gerardi, Agrostis alba* |

The series of dikes within the site have influenced the nature and composition of the vegetation within the site. The landward cells, located in the western portion of the site have been identified as freshwater emergent marsh and are dominated by prairie cordgrass (*Spartina pectinata),* rough-stemmed goldenrod *(Solidago rugosa)* and slender-leaved goldenrod *(Solidago tenuifolia)*. These areas are freshwater wetlands that have been cut off from tidal influence in all but the most severe storm events, and are sustained predominately by precipitation and groundwater discharge. The largest cell closest to the river contains expansive stands of *Phragmites* SP, interspersed in the southern portion of the site with two irregularly shaped areas of remnant native high marsh. The dikes have been identified as upland and contain *Phragmites* as well as some woody growth, including staghorn sumac (*Rhus typhina*), black locust (*Robinia pseudoacacia*) and black cherry (*Prunus serotina*). A complete list of plant species encountered at the site is provided in Table A-1 in Appendix A.

## 2.5 Soils

Information on soils within the restoration site was compiled from published surveys and a detailed field-sampling program. Review of the Soil Survey for Norfolk and Suffolk Counties (SCS, 1989) indicates the soil types mapped within the restoration site are comprised of a combination of the map units, Udorthents (Ue), wet substratum and Ipswich (IP) mucky peat. Udorthents is the soil type most representative of the disturbed soil conditions on the site. Udorthents, wet

substratum are characterized in the soil survey as filled areas that were previously tidal marshes and river flood plains. Depth of this fill within this soil type can range from 2 to 20 feet or more. Ipswich mucky peat, found along the periphery of the site, is a very poorly drained, nearly level soil in tidal marshes and estuaries on Massachusetts Bay. This soil type is characterized by tidal flooding twice daily.

Detailed sampling of the soils within the site was completed during May through July 1998. The focus of this sampling was primarily to determine the depth of the dredge spoil. The field-sampling program utilized the grid pattern established for the topographic survey as described (see Sheet 1 of 3). Soils were investigated by digging soil pits with a spade and using an auger to take core samples. For each soil sample the following characteristics were noted: depth to parent material (fill), soil color (using a Munsell Color Chart), and soil texture. A summary of subsoil characteristics noted during the soil evaluation is presented on Table 2-1.

## 2.6 Hydrology

Information on hydrology within the restoration site was compiled from published tidal datum, hydraulic modeling and field sampling. Information on the water surface elevations, inundation at high and low tides and flow velocities at the site provides an understanding of hydroperiod and a reference to ensure the proper site elevations are achieved in the restoration area.

The site is located on the west bank of the Neponset River, which flows 27 miles from the Neponset Reservoir in Foxboro to Dorchester Bay (Delaney and Wiggin, 1996). The proposed restoration site is located along the lower Neponset River, below the Lower Mills Dam, where the river experiences semi-diurnal tides (~twice-daily cycles).

Based on the NOAA tidal datum for Boston Harbor the mean high water (MHW) and mean higher high water (MHHW) elevations are 5.04 feet and 5.48 feet (NGVD), respectively. The mean tidal range is identified as 9.9 feet. Additional hydraulic modeling of the Neponset River was completed to determine the tidal elevations in the vicinity of the project site, specifically at the mouth of Palmer Creek.

**Table 2-1: Summary of Subsoil Characteristics* – Neponset River Salt Marsh Restoration Project**

| Transect Number | Plot Location | Depth to Organics (in) | SCS Soil Type | Additional Comments |
|---|---|---|---|---|
| 2+70 | C | 41 | Udorthents | |
| 2+70 | D | 42 | Udorthents | |
| 1+60 | B | 30 | Udorthents | |
| 1+60 | C | 46 | Udorthents | |
| 1+60 | D | 48 | Udorthents | |
| 1+60 | E | No data | Udorthents | Plot located in dense *Phragmites* stand |
| 0+00 | 6 feet south | >45+ | Udorthents | Wet coarse sand |
| 0+00 | A | 15-45 | Ipswich | |
| 0+00 | B | 35 | Ipswich | |
| 0+00 | C | 35 | Ipswich | |
| 0+00 | D | 50 | Udorthents | |
| 0+00 | E | 50 | Udorthents | |
| 2+00 | 100 feet south | 20 | Ipswich | |
| 2+00 | A | 18 | Ipswich | |
| 2+00 | B | >20+ | Udorthents | Stony fill; compacted |
| 2+00 | C | >45+ | Udorthents | Silty fine sand. |
| 2+00 | D | 50 | Udorthents | |
| 2+00 | E | 30 | Udorthents | |
| 2+00 vicinity | Depression #1 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 vicinity | Depression #2 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 vicinity | Depression #3 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 vicinity | Depression #4 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 vicinity | Depression #5 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 vicinity | Depression #6 | No fill. | Ipswich | Organic soils – hemic |
| 2+00 | F | >60+ | Udorthents | Original organic layer below 60 inches |
| 4+00 | 75 feet south | 6 | Ipswich | |
| 4+00 | A | >40+ | Udorthents | Original organic layer below 40 inches |
| 4+00 | B | 50 | Udorthents | |
| 4+00 | C | 45 | Udorthents | |
| 4+00 | D | 50 | Udorthents | |
| 4+00 | E | >60+ | Udorthents | Original organic layer below 60 inches |
| 6+00 | 75 feet south | 0-36 | Ipswich | Organic soils – hemic |
| 6+00 | A | 56 | Udorthents | |
| 6+00 | B | 50 | Udorthents | |
| 6+00 | C | >65+ | Udorthents | Original organic layer below 65 inches. |
| 6+00 | D | 0-50 | Ipswich | Organic soils – hemic |
| 8+00 | A | 72 | Udorthents | |
| 8+00 | B | >65+ | Udorthents | Original organic layer below 65 inches |
| 8+00 | C | 45 | Udorthents | |
| 10+00 | A | 0-50 | Ipswich | Organic soils – hemic |
| 10+00 | B | 48 | Ipswich | |
| 12+00 | A | >60+ | Udorthents | Original organic layer below 60 inches |
| 14+00 | A | 7-60+ | Ipswich | |

*Detailed soils information is presented on Field Data Sheets in Attachment B.

***NOAA Tidal Datum for Boston Harbor (elevations in NGVD-29)***

| | |
|---|---|
| Highest Observed Water Level | 10.40 feet |
| Mean Higher High Water (MHHW) | 5.48 feet |
| Mean High Water (MHW) | 5.04 feet |
| Mean Tide Level (MTL) | 0.27 feet |
| Mean Low Water (MLW) | -4.51 feet |

Note: Normal tidal cycle period is 12.4 hours

A hydraulic analysis of the Neponset River in the vicinity of the restoration site was completed as part of a bridge scour evaluation of the I-93 Bridge for the Massachusetts Highway Department, also being completed by Earth Tech. The factors used in the analysis were derived from a one-dimensional, unsteady flow hydraulic model (HEC-UNET) developed by the U.S. Army Corps of Engineer's, Hydraulic Engineering Center. This analysis involved modeling of the river hydraulics and hydrology at various tidal stages and storm events. Information on peak flows used in the modeling were obtained from published FEMA Flood Insurance Studies of the city of Boston and Milton and tidal data for the NOAA's Boston Harbor tidal gauge (MA 884 3970). The hydraulics of the river channel were modeled along a series of cross-sections. The results of this modeling indicated that the water elevations, tide ranges and flood synchronicity (lag) at the restoration site (Palmer Creek) are similar to that at the mouth of the Neponset River at Dorchester Bay (see above table). These findings have been validated with on-site tide gauges readings in Palmer Creek during December 1999 and January 2000.

As previously described, the site is enclosed by perimeter dikes. These dikes functionally isolate the restoration site and restrict the movement of tidal waters into the site. Palmer Creek, located along the northern portion of the site, overflows its banks during high tides to flood a small area of the site adjacent to the MWRA easement. Another small ditch, located along the southern edge of the site, appears to flood the southern-most limits of the site but only during extreme high tides. Several shallow ditches within the interior of the site also function to drain water from the site. Hydrology within the interior of the site appears to be influenced more by precipitation and groundwater interaction than by regular tidal exchange.

Supplemental hydrologic investigations were completed during May through July 1998. The field-sampling program utilized the grid pattern established for the topographic survey as described. Hydrological information collected included: site inundation, depth of surface water, and depth to water table. Additional comments such as distance to channel or river, width and depth of channel or pool flow characteristics, and hydrologic constrictions were also noted, if applicable. A summary of hydrological characteristics noted during this evaluation is presented on Table 2-2.

**Table 2-2: Summary of Hydrological Characteristics – Neponset River Salt Marsh Restoration Project**

| Transect Number | Plot Location | Depth to Water Table (in) | Date Collected | Time | Daily Tide (high/low) | Tidal Cycle[1] |
|---|---|---|---|---|---|---|
| -2+70 | C | >41" | 7/28/98 | 2:05 p.m. | H -3:24 p.m. | F |
| -2+70 | D | >42" | 7/28/98 | 2:20 p.m. | H -3:24 p.m. | F |
| -1+60 | B | 31" | 7/28/98 | 12:50 p.m. | H -3:24 p.m. | F |
| -1+60 | C | >46" | 7/28/98 | 1:10 p.m. | H -3:24 p.m. | F |
| -1+60 | D | >48" | 7/28/98 | 1:30 p.m. | H -3:24 p.m. | F |
| -1+60 | E | no data | 7/28/98 | 2:00 p.m. | H -3:24 p.m. | F |
| 0+00 | 6' south | 4" | 5/26/98 | 8:45 a.m. | H -12:23 p.m. | F |
| 0+00 | A | 8" | 6/9/98 | 8:55 a.m. | H -11:46 a.m. | F |
| 0+00 | B | no data | 6/9/98 | 9:40 a.m. | H -11:46 a.m. | F |
| 0+00 | C | >40" | 6/9/98 | 10:04 a.m. | H -11:46 a.m. | F |
| 0+00 | D | 18" | 6/9/98 | 10:25 a.m. | H -11:46 a.m. | F |
| 0+00 | E | 16" | 6/9/98 | 11:00 a.m. | H -11:46 a.m. | F |
| 2+00 | 100' south | 9" | 5/26/98 | 10:06 a.m. | H -12:23 p.m. | F |
| 2+00 | A | 18" | 6/9/98 | 4:15 p.m. | L - 5:39 p.m. | E |
| 2+00 | B | >20" | 6/9/98 | 4:30 p.m. | L - 5:39 p.m. | E |
| 2+00 | C | 2" | 6/9/98 | 2:10 p.m. | L - 5:39 p.m. | E |
| 2+00 | D | 4" | 6/9/98 | 3:10 p.m. | L - 5:39 p.m. | E |
| 2+00 | E | 6" | 6/9/98 | 12:00 p.m. | L - 5:39 p.m. | E |
| 2+00 | Depression #1 | 6" | 7/28/98 | 3:05 p.m. | H -3:24 p.m. | F |
| 2+00 | Depression #2 | 3" | 7/28/98 | 3:20 p.m. | H -3:24 p.m. | F/H |
| 2+00 | Depression #3 | 20" | 7/28/98 | 3:28 p.m. | H -3:24 p.m. | H/E |
| 2+00 | Depression #4 | 7" | 7/28/98 | 3:35 p.m. | H -3:24 p.m. | E |
| 2+00 | Depression #5 | 5" | 7/28/98 | 3:40 p.m. | H -3:24 p.m. | E |
| 2+00 | Depression #6 | 6" | 7/28/98 | 3:50 p.m. | H -3:24 p.m. | E |
| 2+00 | F | >60" | 6/9/98 | 12:50 p.m. | L - 5:39 p.m. | E |
| 4+00 | 75' south | 7" | 5/26/98 | 10:33 a.m. | H -12:23 p.m. | F |
| 4+00 | A | >40" | 6/9/98 | 3:40 p.m. | L - 5:39 p.m. | E |
| 4+00 | B | 8" | 6/11/98 | 10:30 a.m. | H - 1:07 p.m. | F |
| 4+00 | C | 8" | 6/11/98 | 11:06 a.m. | H - 1.07 p.m. | F |
| 4+00 | D | >10" | 6/11/98 | 11:26 a.m. | H - 1.07 p.m. | F |
| 4+00 | E | 20" | 6/11/98 | 11:47 a.m. | H - 1.07 p.m. | F |
| 6+00 | 50-75' south | >36" | 5/26/98 | 10:53 a.m. | H -12:23 p.m. | F |
| 6+00 | A | >56" | 6/11/98 | 1:09 p.m. | H - 1.07 p.m. | H |
| 6+00 | B | >50" | 6/11/98 | 1:38 p.m. | H - 1.07 p.m. | H/E |
| 6+00 | C | >65" | 6/11/98 | 2:00 p.m. | L - 7:02 p.m. | E |
| 6+00 | D | 10" | 6/11/98 | 2:20 p.m. | L - 7:02 p.m. | F |
| 8+00 | A | 16" | 6/24/98 | 8:25 a.m. | H -12:07 p.m. | F |
| 8+00 | B | 35" | 6/24/98 | 10:05 a.m. | H -12:07 p.m. | E |
| 8+00 | C | >45" | 6/11/98 | 3:30 p.m. | L - 7:02 p.m. | E |
| 10+00 | A | Inundated | 6/24/98 | 3:25 p.m. | L - 6:03 p.m. | E |
| 10+00 | B | 36" | 6/11/98 | 3:45 p.m. | L - 7:02 p.m. | E |
| 12+00 | A | 19" | 6/24/98 | 1:55 p.m. | L - 7:02 p.m. | E |
| 14+00 | A | Inundated | 6/24/98 | 2:45 p.m. | L - 7:02 p.m. | E |

[1] Tidal Cycle = L (Low), H (High), E (Ebb), F (Flood)

## 2.7 Salinity

Information on salinity within the restoration site was compiled through sampling of surface water and soil water. Site specific information on the water and soil salinities is important in choosing the most favorable conditions for the development of salt marsh plants. Salinities in estuaries can range from a little as 0.5 parts per thousand (ppt) to upwards of 30 ppt. It is recognized that salinities in surface water exceeding 18 ppt (polyhaline = 18-30 ppt) can inhibit the growth of *Phragmites australis*. These higher salinities would also encourage the colonization of salt tolerant plants.

The field sampling within the site was completed during December 1998 and January 1999 at various periods during the tidal cycle. Surface water salinity data was collected along Palmer Creek, an unnamed creek, and existing pools. Results of this sampling are presented on Table 2-3 and show a range of salinity from 15-26 ppt with a mean range of 16-26 ppt. Additional sampling in surface waters in the Neponset River and Palmer Creek in the vicinity of the site completed in July and August 1998 (Vernon Woodworth) ranged from 7.6 to 25.7 ppt.

Soil water salinity data were collected from a series of wells installed at the project site (see Figure 2-3). These PVC wells were installed at the site in nests of three with collection holes at three depths (according to UNH-Mass Audubon specifications). The "shallow" wells (S) contained holes ranging from 5-20 centimeters (cm) below ground level, "medium" wells (M) had holes from 35-50 cm, and "long" wells (D) had holes from 65-80 cm below ground level. Results of sampling are presented on Table 2-4 and show a range of salinity from 1-27 ppt.

**Table 2-3: Summary of Surface Water Salinity Data Collected in December 1998 and January 1999 – Neponset River Salt Marsh Restoration Project**

| Tide Cycle | Ebb | Flow | Flow | Flow | @ H-Tide (full moon) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Well # | 12/4/98 | 12/13/98 | 12/28/98 | 12/29/98 | 1/1/99 | HI | Low | Mean | Location |
| A | NA | NS | 25 | NS | NA | 25 | 25 | 25 | Palmer Creek @ Wells 1&2 |
| B | 26 | 18 | 21 | NS | 26 | 26 | 21 | 23 | Palmer Creek @ Culvert (downstream) |
| C | NS | NS | NS | NS | 26 | 26 | 26 | 26 | Upper Palmer Creek near Well 7 |
| D | 20 | NS | NS | NS | 25 | 25 | 20 | 23 | Near Well 6 |
| E | 16 | NS | NS | NS | NA | 16 | 16 | 16 | Pool near Well 5 |
| F | 15 | 15 | 16 | NS | NA | 16 | 15 | 16 | Creek 50ft E of Well 14 |
| G | 20 | 18 | 15 | NS | NA | 20 | 15 | 18 | Creek @ Wier Near Well 15 |

Figure 2-3: Location of Soil Water and Surface Water Salinity Sampling Locations

**Table 2-4: Summary of Soil Water Salinity Data Collected in December 1998 and January 1999 – Neponset River Salt Marsh Restoration Project**

| Tide Cycle | Ebb | Flow | Flow | Flow | @ H-Tide | | | |
|---|---|---|---|---|---|---|---|---|
| Well # | 12/4/98 | 12/13/98 | 12/28/98 | 12/29/98 | 1/1/99* | HI | Low | Mean |
| S1 | ND | 22 | 20 | 26 | NS | 26 | 20 | 23 |
| M1 | ND | 18 | 22 | 25 | NS | 25 | 18 | 22 |
| L1 | ND | 18 | 18 | 18 | NS | 18 | 18 | 18 |
| S2 | ND | 15 | 16 | 20 | NS | 20 | 15 | 17 |
| M2 | ND | 13 | 20 | 21 | NS | 21 | 13 | 18 |
| L2 | ND | 15 | 17 | 20 | NS | 20 | 15 | 17 |
| S3 | 1 | NS | ND | 10 | NS | 10 | 1 | 6 |
| M3 | 1 | NS | ND | ND | NS | 1 | 1 | 1 |
| L3 | NA | NS | 2 | ND | NS | 2 | 2 | 2 |
| S4 | 15 | NS | 16 | 18 | NS | 18 | 15 | 16 |
| M4 | 22 | NS | 22 | 26 | NS | 26 | 22 | 23 |
| L4 | 21 | NS | 22 | 25 | NS | 25 | 21 | 23 |
| S5 | 14 | 16 | 14 | 16 | NS | 16 | 14 | 15 |
| M5 | 14 | 15 | 15 | 15 | NS | 15 | 14 | 15 |
| L5 | 20 | 20 | 17 | 20 | NS | 20 | 17 | 19 |
| S6 | 13 | NS | 14 | 12 | NS | 14 | 12 | 13 |
| M6 | No M Well | No M Well | No M Well | No M Well | No M Well | NA | NA | NA |
| L6 | No L Well | No L Well | No L Well | No L Well | No L Well | NA | NA | NA |
| S7 | 20 | NS | 22 | 21 | NS | 22 | 20 | 21 |
| M7 | 24 | NS | 23 | 24 | NS | 24 | 23 | 24 |
| L7 | 25 | NS | 25 | 20 | NS | 25 | 20 | 23 |
| S8 | 19 | NS | 18 | NS | NS | 19 | 18 | 19 |
| M8 | 16 | NS | ND | NS | NS | 16 | 16 | 16 |
| L8 | 16 | NS | 16 | NS | NS | 16 | 16 | 16 |
| S9 | NA | NS | 12 | NS | NS | 12 | 12 | 12 |
| M9 | 22 | NS | 21 | NS | NS | 22 | 21 | 22 |
| L9 | 12 | NS | 16 | NS | NS | 16 | 12 | 14 |
| S10 | ND | NS | ND | ND | NS | NA | NA | NA |
| M10 | ND | NS | ND | ND | NS | NA | NA | NA |
| L10 | ND | NS | ND | ND | NS | NA | NA | NA |
| S11 | ND | NS | ND | ND | NS | NA | NA | NA |
| M11 | ND | NS | ND | ND | NS | NA | NA | NA |
| L11 | ND | NS | ND | ND | NS | NA | NA | NA |
| S12 | NS | 15 | 14 | NS | NS | 15 | 14 | 15 |
| M12 | NS | 15 | 15 | NS | NS | 15 | 15 | 15 |
| L12 | NS | 15 | 16 | NS | NS | 16 | 15 | 16 |
| S13 | NS | ND | ND | ND | NS | NA | NA | NA |
| M13 | NS | ND | ND | ND | NS | NA | NA | NA |
| L13 | NS | ND | ND | ND | NS | NA | NA | NA |
| S14 | 12 | 15 | 12 | 15 | NS | 15 | 12 | 14 |
| M14 | 15 | 15 | 14 | 15 | NS | 15 | 14 | 15 |
| L14 | 15 | 16 | 15 | 12 | NS | 16 | 12 | 15 |
| S15 | NA | 12 | 14 | 15 | NS | 15 | 12 | 14 |
| M15 | 15 | 12 | 14 | 15 | NS | 15 | 12 | 14 |
| L15 | 15 | 16 | 15 | 14 | NS | 16 | 14 | 15 |
| S16** | 19 | NS | NS | NS | NS | 19 | 19 | 19 |
| M16 | 21 | 19 | 21 | 20 | NS | 21 | 19 | 20 |
| L16 | 25 | 25 | 27 | 27 | NS | 27 | 25 | 26 |

*Full moon tide ** no S well; sampled surface water

# 3. DEVELOPMENT OF FINAL RESTORATION PLAN

## 3.1 Basis of Final Restoration Plan

The specific goals and objectives of the project have defined the basis of the Final Restoration Plan. Satisfying these goals requires developing a plan with a sound approach and supported by proven ecological and engineering principles. Restoration of natural ecosystems, particularly in estuary environments, is challenging due to dynamic coastal processes. It is important to recognize that the restoration in this setting will be a gradual and long-term process. We would expect the first several years following construction to be a period of site stabilization and partial revegetation.

The *Final Restoration Plan* has identified those site conditions that are significant to a successful restoration. The restoration plan focuses on establishing sufficient overall site conditions, encouraging natural processes and accelerating the marsh evolution. The elements of the restoration are intended to be flexible. The background information on existing conditions provides guidance in the design development. However, we envision an adaptive restoration approach, which may involve refinements of the project during construction stages.

As previously mentioned, MDC is coordinating with other agencies in the partnership that has formed around this project. Proceeding through the restoration planning and design stages with this partnership has provided resources and technical expertise that has added value to the project. The following agencies and interest groups have played a role in this planning: The National Marine Fisheries Service, EPA, Army Corps of Engineers, WRBP and the Friends of the Neponset River Estuary. Comments received from these partners have been incorporated into the *Final Restoration Plan*, as appropriate.

The major components of this restoration plan are based on successful elements of similar salt marsh restoration projects. Other projects involving the restoration of degraded salt marsh have focused on the eradication of *Phragmites australis* through the increase in tidal exchange and establishment of proper marsh elevations. Improving the tidal exchange will increase hydrologic interaction and salinities entering the site. These conditions should encourage native salt tolerant marsh species, and discourage the growth and expansion of the *Phragmites australis*. However, the restoration process on the site can be enhanced through the aggressive control of *Phragmites australis*. A detailed discussion of these proposed approaches is found in Section 3.2 of this plan.

The total area targeted for the restoration effort encompasses approximately 20 acres. The initial phases will includes the restoration of approximately 1.2 acres for the Savin Hill/Malibu Beach mitigation commitment. Subsequent phases may include

replacing the culvert pipes under the existing MWRA easement along the northern border of the site, and additional dike breaching and excavation to "low marsh" elevation which could improve the tidal restrictions to the salt marsh area north of the site.

## 3.2 Restoration Schemes

### *3.2.1 Criteria for Restoration Schemes*

The following section provides a summary of the restoration criteria and the restoration schemes considered during the preliminary restoration planning process. The purpose of identifying these criteria is to achieve a balance among competing project goals. Below is a list of the criteria that were applied to the preferred restoration scheme. The restoration project should:

- Optimize restoration within diked areas dominated by *Phragmites*;
- Maximize tidal exchange with high salinity flows;
- Avoid alterations to existing high functioning wetland areas;
- Maintain existing remnant salt marsh areas within site;
- Establish "low salt marsh" elevations between MLW and MHW;
- Create a variety of habitats (ditches, pannes, pools) of varying depth;
- Encourage site conditions that discourage the future invasion of *Phragmites* into restoration areas;
- Relocate all excavated material on-site;
- Target soil disposal in areas with low habitat value; and
- Optimize features of the disposal areas to blend into landscape.

### *3.2.2 Use of Ecological Benchmarks*

The use of ecological benchmarks was used in the restoration planning for this project as a reliable reference in establishing a healthy marsh system. The existing native low marsh areas located immediately adjacent to the Neponset River and the areas of remnant salt marsh within the restoration site will serve as benchmarks for the restoration. Representative marsh elevations and salinities have been recorded in these areas. Using this information will create characteristics in the restoration site similar to those existing productive habitats. The dimensions and depths of the proposed creek and ditches have been developed to mimic those found in the healthy portions of the marsh. The long-range vision of the restoration site is seen as a gradual succession into a productive salt marsh community dominated by native plant species. By restoring the hydrology and vegetative structure/ composition of the site, functions and values such as fisheries and wildlife habitat, floodflow alteration, storm damage prevention and recreational opportunities can be enhanced.

### 3.2.3 Selection of the Mitigation Site

The area selected for the mitigation of the Savin Hill/Malibu Beach project occurs in the extreme northwest corner of project site (see Appendix B). The area is characterized as an isolated pocket of *Phragmites*, which is approximately 1.2 acres. A small ditch, which extends from Palmer Creek ends just prior to reaching this area. The area to the east is comprised of existing saltmarsh. The mitigation area is higher in elevation than the surrounding salt marsh areas. It was determined that this portion of the project site has the greatest potential for successful mitigation based upon several factors:

- The area presently contains a dense stand of *Phragmites* indicating low habitat value.
- This stand of *Phragmites* appears to be slowly encroaching toward the remnant salt marsh area, suggesting the salt marsh may be at risk from further intrusion.
- The area is underlain by dredge spoil.
- The area is close to Palmer Creek and the associated high salinity tidal flows.
- The area occurs adjacent to an existing ditch that can provide an improved source of tidal flows with minimum alteration.

### 3.2.4 Hydrologic Considerations

The final restoration plan is based primarily on re-establishing tidal flows by removing obstructions and creating/extending ditches. The ditches will be designed to allow tidal flows to overtop the ditch banks and flow into the *Phragmites* stands during high tides, but will provide drainage at low tide. Observed hydroperiods in the adjacent low salt marsh suggests the estuary is likely to be flood dominant. This assumption is suggested by the rapid wetting of the marshes followed by a slow drying period.

Large-scale excavation will be required to ensure the targeted restoration area is located at an appropriate elevation. The primary creek and ditches are designed to provide flows to the lower portions of the site, which were determined to have a higher likelihood of successfully establishing native salt marsh. Several ditching patterns were considered. The location and width of the creek and ditches will provide physical barriers to discourage the encroachment of *Phragmities* from adjacent areas. It was determined to be important that the primary ditch (creek) extend from Palmer Creek, to ensure capture of highest salinity flows. It was also determined to be important that the ditches lead to several pools that could provide finfish habitat as well as habitat for wading birds. The proposed smaller ditches will be constructed to be sinuous but will eventually seek a final footprint through natural processes. Siting the restoration area around the existing salt marsh provides the

advantage of a uniform hydroperiod, proximity to an ecological benchmarks and proximity to a viable seed bank of native salt marsh plants.

### 3.2.5 Disposal of Excavated Material

Excavation of the dredge spoil overburden across the entire restoration site was determined to be impractical given the amount of excavation necessary and the requirement that disposal be on-site. During the initial planning stages the diked cells along the western limits of the site were thought to provide the best opportunity for relocation of the spoils. However, after consultation with the Corps of Engineers it was determined that these areas were considered jurisdictional freshwater wetlands with potential habitat value, and, therefore, not suitable for disposal areas. In light of these constraints, with the guidance of DEP regulatory staff, it was determined that the higher elevations within the restoration site dominated nearly exclusively by *Phragmites* stands would be targeted for relocation of the spoil. The areas within the site that meet that description are found in the northern portion of the site. Further consideration in the relocation of the spoil was the need to blend the disposal areas into the existing landscape and viewsheds. This will be accomplished by creating an irregular border and revegetating the area to provide a habitat island and scenic vistas. Given all these considerations, a single disposal area was selected in the northern portion of the site that will incorporate an existing slightly raised upland island created during the previous dredge and disposal operations.

## 3.3 Details of the Final Restoration Plan

### *3.3.1 General Sequence of Construction*

The following is a proposed sequence to guide the restoration effort:

- Establish access routes, soil disposal area in the field.
- Demarcate limits of work and areas of existing salt marsh within the site to be maintained.
- Install temporary bridge and swamp mats for crossing existing creek and marsh areas (prior approval by MDC). Remove structures and restore disturbed areas to original conditions.
- Mow *Phragmites* within limits of restoration area, proposed ditches and disposal area. Cut to approximately 6-inches and remove stems.
- Follow-up with treatment of herbicide on cut stems to weaken rootstock.
- Create temporary berms along the southern edge of the site in areas where tidal flooding can be controlled and minimize flooding.
- Stake out the location of ditches, pools, pannes and areas to be excavated.
- Establish grade stakes for rough elevations for proposed marsh surface.
- Prepare spoil disposal area and install erosion and sedimentation controls around perimeter.
- Avoid work during lunar tides and other extreme high water conditions.

- Use specialized construction equipment (long reach excavators, hydraulic dredge, ect…) as necessary, for excavation and site work.
- Excavate overburden in surrounding marsh to achieve proposed marsh surface elevations.
- Establish gentle sloping of marsh plain towards creek, ditches, pools and pannes of approximately 0.01%.
- Excavate pools, pannes and secondary ditches within the site, including ditches behind the dike breaches.
- Dewater portions of the site, as necessary, using temporary pits.
- Survey final elevations as construction progresses through site.
- Relocate excavated material and shape disposal area according to plan.
- Excavate primary creek from south to north towards Palmer Creek. Do not establish connection with Creek.
- Plant slopes of newly formed creek and primary ditches with *Spartina alterniflora.*
- Upon final grading and completion of pools, pannes and ditches, complete connections to Palmer Creek and stabilize creek slopes with riprap, fiber rolls and erosion control blankets.
- During the same time as establishing the connection to Palmer Creek create breaches in the perimeter dikes. Stabilize slopes adjacent to breaches with erosion control blankets.
- Stabilize disposal area with erosion control materials (silt fence, geotextile fabric) and revegetate according to plan.
- Follow-up with selective herbicide treatment as needed.

### *3.3.2 Control of Phragmites*

The dominant species of plant found within the restoration site is common reed *(Phragmites australis). Phragmites* is a tall, perennial rhizomatous grass, which grows up to 16 feet or more. It has broad, flat leaf blades, a large terminal inflorescence and fleshy horizontal rhizomes. The rhizomes found from 1-3 feet underground allow the stand to expand while the aboveground vertical rhizomes transform into the aerial shoots. Young stands often have surface rhizomes as well.

Successful management of this species is dependent on proper identification and correction of the factors that led to *Phragmites* colonization of the site. In the restoration site, tidal restrictions have decreased flooding and salinities, effectively encouraging the spread of *Phragmites* and overtaking the native salt marsh grasses. The restoration plan recommends the use of a combination of methods including mowing, select herbicide applications and manipulation of water levels and salinity. The following is a description of the preferred methods that will be used to control *Phragmites* within the site. These practices implemented at the appropriate time of the year should retard the growth of *Phragmites* during the initial years of revegetation of the restoration site.

***Cutting*** – Cutting will be initiated as the first and primary measure to irradicate *Phragmites* from the marsh plain. Cutting will take place after tasseling when the plant is supplying nutrients to the rhizomes (August). This is when most of the food reserves are stored within the stems. Cutting during this period will reduce the stands' vigor. Cutting will also function to make the site more accessible during the construction phases. The excavation of the site and relocation of the disposal area will serve to remove the mass of the rhizomes from the restoration area.

***Select Herbicide Treatment*** – Following the cutting, select herbicide application is proposed along the dikes and edges of the remnant salt marsh areas within the restoration site. The herbicide most appropriate for application in this setting is Rodeo™. Rodeo is a water solution of the isopropylamine salt of glyphosphate. This herbicide is developed for use in wet environments but it is not selective and will also kill grasses and broadleaf plants to which it is applied. Toxicity tests indicate it is non-toxic to aquatic animals. The stems of the plants will wilt, turn yellow then brown and eventually deteriorate. Aerial spraying can be effective for large stands, but for smaller stands such as this site, spraying of individual plants by hand with a backpack sprayer is more appropriate. This backpack application will minimize the potential harm to healthy salt marsh plants within the site. Additional select herbicide application may be required in subsequent years to inhibit colonization until the site is revegetated.

***Manipulation of Water Level and Salinity*** – Once grading and dikes have been breached the means to control *Phragmites* within the restoration site will be accomplished through the increase of tidal flows and salinities. As previously mentioned, salinities in surface water exceeding 18 ppt can inhibit the growth of *Phragmites*. Surface water salinity data collected along Palmer Creek and within the site found salinities ranging from 15-26 ppt. These higher salinities would also encourage the colonization of salt tolerant plants.

### *3.3.3 Grading and Erosion/Sedimentation Controls*

Following the initial site preparation activities the rough grading of the restoration site will commence. The rough grading will focus on removing the decaying *Phragmites* stock and establishing the desired marsh elevations. Low marsh areas are characterized by flats dominated by *Spartina alterniflora* and subject to regular flooding (semi-diurnal) with elevations approximately 1 foot below mean high water (MHW). In an effort to encourage the development of low marsh habitat the elevations of the marsh will be established at approximately 4 feet (NGVD). This elevation has been identified based on the MHW surface elevation (5.04 feet) and the adjacent ecological benchmarks in the field.

The area targeted for restoration to achieve these elevations is approximately 11 acres. This area has been defined due to its proximity to adjacent salt marsh and the

need to excavate less than 1.5 feet of overburden material to achieve desired elevations. Specialized equipment used in the excavation and grading may include low ground pressure excavators, long-reach excavators, small dozers and clamshell buckets. It may be necessary in some areas to work off of timber mats.

Controlling erosion and sedimentation during construction within the restoration site will be handled primarily through the sequencing of operations. Areas of existing salt marsh within the site will be protected by the installation of silt fence around the perimeter. Prior to earthwork, areas of the site subject to flooding will be temporarily diked. This measure will allow a continuous construction operation by reducing the amount of standing water on the site. In addition, the last task in the construction will be the breaching of the dikes and the connection of the new and expanded ditches to Palmer Creek. The essentially closed site will function to control the movement of sediments in to the river or adjacent marsh.

### *3.3.4 Pannes and Pools*

The restoration plan includes the creation of three deep pools and three shallow pannes scattered throughout the site. The pools will be approximately 3,200 square feet in size, with a maximum depth of 2.6 feet. The bottom of the pools will be established at elevation 1.4 feet (NGVD). The pools will be hydrologically connected to the series of lateral ditches that flood and drain the site. This design is intended to provide permanent standing water at a depth sufficient to support finfish, shellfish and other macroinvertebrate communities. The edges of the pools will be gradually sloped to encourage the development of *Spartina alterniflora* along the lateral fringes. This vegetative feature should provide ample shading and reduce evapotranspiration. The pannes will be approximately 800 square feet in size, with a maximum depth of 1.5 feet. The pannes are intended to increase the overall habitat value of the restored marsh. The edges of the pools and pannes will be irregular with gently sloping depressions.

### *3.3.5 Channel Construction (creeks and ditches)*

The primary channel (creek) will be constructed along the western limits of the site. The creek will be approximately 800 linear feet and 8 feet wide, bank to bank. The channel is designed as a side step channel approximately 2.5 feet deep with moderate slopes of 2:1. This design is most efficient to construct and will reduce the slough of the banks. The bottom elevation will be constructed to maintain a base volume of several inches at slack tides. In order to prevent slumping and erosion of the creek, the slopes will be revegetated with *Spartina alterniflora.*

The restoration also incorporates a series of new ditches and expansion of existing ditches (approximately 1,300 linear feet). These ditches will extend into the interior of the site and connect to the primary pool. An existing ditch, located parallel to the

southern dike, will be widened and extended along the southwest perimeter of the mitigation site and will connect with the primary creek. The size and dimensions of the ditches will vary depending on their location within the site and the relationship to the flow velocities.

A small ditch in the southeast corner of the site contains a wooden spillway that will be removed. The spillway restricts regular tidal inundation and only allows the tide to flood the corner of the site in high high tides. Removal of these boards will eliminate a tidal restriction at a critical area in the marsh and allow tidal flows into larger portions of the restoration and mitigation area.

### *3.3.6 Planting of Creek Banks*

The slopes of the proposed creek will be planted with salt marsh grass (*Spartina alterniflora).* The *Spartina alterniflora* plugs (2" peat pots) will be installed in a staggered pattern along the upper portions of the bank. The planted slopes will provide retention and control of sediment transport off the marsh plain. In addition, the *Spartina alterniflora* should serve as a seed source for revegetation of the restoration site. Revegetation on the remaining portion of the restoration site is anticipated through natural recruitment of seed sources from the adjacent marshes in the estuary.

### *3.3.7 Removal of Dikes*

The excavation of breaches along the perimeter dikes will provide an additional direct hydrologic connection to the adjacent Neponset River. These breaches will enhance tidal cycling and improve tidal flows to former salt marsh communities landward of the dike. The plan identifies a total of six breaches located at intervals no less than 150 feet along the dike. The breaches will be approximately 30 feet wide with two located along the eastern dike closest to the river, two along the southern dike and one along the northern dike bordering Palmer Creek. In order to avoid unnecessary erosion landward of the breaches, small ditches will be extended from the breaches into the site. These ditches will be excavated prior to the removal of the dike section to minimize erosion during construction.

### *3.3.8 Relocation of Excavated Material*

The material excavated from the marsh, pools, pannes, dikes and channels will be relocated to the northern portion of the site, within an area containing very dense stands of *Phragmites*. This area was selected for disposal since it contains low habitat value and relatively high elevations (7-9 feet NGVD), making it an unlikely area for future restoration. The amount of excavated material is estimated to be approximately 46,700 cubic yards. The designated disposal area is approximately

3.3 acres. This translates into covering the existing area by approximately 20 feet of material.

The disposal area is proposed to be graded and vegetated with native upland species to create an upland island, upon completion of the overall restoration project, thereby improving its overall habitat value. The specific details of the revegetation of the disposal area will be detailed in the construction specifications. The total area of *Phragmites* community proposed to be altered within the disposal site is anticipated to be approximately 2 acre. Access to the disposal area will be restricted along a designated haul route along the western dike. (This temporary haul route will be excavated and become the primary creek).

## 3.4 Post-Construction Monitoring

Post-construction monitoring will be implemented to track the progress of the restoration. The details of the post-construction monitoring plan will be finalized as part of the permitting for the restoration project. The details of the monitoring as discussed below are based on the mitigation guidance developed by the Corps of Engineers New England District. The findings of the monitoring events will be prepared in a summary report and submitted to the stakeholders and regulatory agencies involved in the project.

The annual monitoring will focus on the vegetation cover types, extent and condition of the *Phragmites* and the salinity in the site. The sampling stations established as part of the existing condition survey could be used to compare post-construction site features. In addition, site photos and aerial photos will provide a record of the overall restoration progress. It is envisioned that much of the monitoring effort will be conducted by a collective group of interested parties. The continued participation of the volunteers in the project will continue to provide added value.

For each of the first three full growing seasons following construction of the mitigation site, the site will be monitored and monitoring reports submitted to the stakeholders no later than December 15 of the year being monitored. The first year of monitoring will be the first year that the site has been through a full growing season after completion of construction and planting. For these special conditions, the growing season is assumed to starts no later than May 31.

Remedial measures will be implemented to attain the four success standards described below within three growing seasons after completion of construction of the mitigation site.

1) At least three-quarters of all planting cells at each mitigation site should have at least 35% planting survival. This criteria will be used along the planted creeks within the mitigation site. This criteria will be addressed by calculating the